072550

RA

FRENCH LIMITED SITE
CROSBY, TEXAS

DNAPL INVESTIGATION PRELIMINARY REPORT

Submitted to:

FLTG, Inc.
Crosby, Texas

Submitted by:

Applied Hydrology Associates, Inc.
Denver, Colorado

June 1992

24

072551

TABLE OF CONTENTS

		Page
1.0	Introduction	1
1.1	Background	1
1.2	Conceptual Model of DNAPL Migration	1
2.0	April 1992 Investigation	2
2.1	S1-16 Area	3
2.2	INT-11 Area	4
2.3	Area Inside Floodwall	6
3.0	Summary and Conclusions	6

Figures

1 - DNAPL Investigation Location Map
2 - Location Map, DNAPL Investigation, S1-16 Area
3 - Cross Sections A-A' & B-B', DNAPL Investigation, S1-16 Area
4 - Structure on the C1 Interval, DNAPL Investigation, S1-16 Area
5 - C1 Clay Isopach (Ratio % > 3), DNAPL Investigation, S1-16 Area
6 - DNAPL Occurrence in the S1 interval, DNAPL Investigation, S1-16 Area
7 - Location Map, DNAPL Investigation, INT-11 Area
8 - Cross Section C-C', DNAPL Investigation, INT-11 Area
9 - C1 Clay Isopach (Ratio % > 3), DNAPL Investigation, INT-11 Area
10 - Structure on the C1 Interval, DNAPL Investigation, INT-11 Area
11 - Structure on the C2 Interval, DNAPL Investigation, INT-11 Area
12 - DNAPL Occurrence in the INT interval, DNAPL Investigation, INT-11 Area

Tables

1 - Summary of Soil Sample Analyses, S1-16 and INT-11 Areas
2 - Sample Descriptions, S1-16 and INT-11 Areas
3 - Volatile Organic Analyses, Well INT-64, INT-11 Area
4 - Analysis of Soil Samples from INT-11B and INT-11C

Appendices

1 - Analytical Reports - S1-16 DNAPL samples
2 - Cone Penetrometer Logs - S1-16 Area
3 - Cone Penetrometer Logs - INT-11 Area
4 - Boring Log and Well Construction Details for REI-6-1
5 - Analytical Reports - INT-11B and INT-11C DNAPL samples

072552

1.0 INTRODUCTION

This report describes the detailed results of an initial investigation conducted in the S1-16 and INT-11 well areas in April 1992 to delineate the extent of free-phase organic liquid. Major results of this investigation were first presented in the April 1992 Monthly Progress Report.

1.1 Background

The geology of the French Limited site is divided into three zones[1]: the lower silty sand zone, the middle clayey zone, and the upper alluvial zone. The lower silty sand zone is a confined aquifer, the top of which is between 109 and 137 feet below ground surface (BGS). It is separated from the upper alluvial zone by the middle clayey zone, a 60- to 90-foot-thick aquitard, referred to as the C2 clay. The upper alluvial zone is up to 55 feet thick. It is subdivided into a lower water-bearing zone of interbedded sands, silts, and clays (the INT unit), an upper sandy water-bearing zone (the S1 unit), and a clay aquitard (the C1 unit) that separates the INT and S1 units. Contaminated groundwater at the site is limited to the S1 and INT units, and is being remediated by a combination of source cleanup (lagoon bioremediation), physical and hydraulic source migration controls (a sheet-pile migration control wall and an inward-gradient groundwater extraction system), groundwater extraction and surface treatment using a fixed-film bioreactor, and in-situ bioremediation using a system of injection wells.

Dense non-aqueous phase liquids (DNAPLs) were first detected at the S1-16 and INT-11 production wells in January, 1992, shortly after initiation of the production well system in early January 1992. Well S1-16 is located inside the floodwall at the southeast end of the lagoon: well INT-11 is located outside the floodwall, east of center of the south side of the lagoon (see Figure 1).

A sample of DNAPL was collected from S1-16 in January 1992 and analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total organic carbon (TOC), total petroleum hydrocarbons (TPH), and total chlorinated hydrocarbons (TOX). The results of these analyses are presented in Appendix 1. The sample contained high concentrations of VOCs including chloroform (7.8%), 1,2-DCA (6.5%), carbon tetrachloride (2%), 1,1-DCA (0.2%), 1,2-DCE (0.2%), and TCE (0.1%), and tentatively identified compounds (TICs) including bromochloromethane (2.5%) and 1,4-difluorobenzene (2.3%). Therefore, total VOCs exceeded 20%. The sample also contained high concentrations of SVOCs including naphthalene (0.5%).

A sample of DNAPL was collected from well INT-11 in March 1992. The analysis of this sample has not yet been reported by the laboratory.

The April 1992 investigation was intended to follow up these indications of DNAPLs, and was conducted in two areas: around well S1-16, and around well INT-11. The aim of the investigaton was to define the extent of free DNAPL outside the floodwall. The two areas investigated are shown on Figure 1.

1.2 Conceptual model of DNAPL migration

There are two mechanisms that may account for the presence of DNAPLs in borings near the French Lagoon:

1) Migration as a separate phase directly from the lagoon; and/or
2) Mobilization of organic constituents near the lagoon due to their increased solubility in the presence of organic solvents, followed by deposition further away from the lagoon due to decreasing solvent concentrations and lower solubility[2].

---

[1] For more details, see *Hydrogeologic Assessment Report*, March, 1989, Chapters 2 and 3.

[2] This mechanism is described in more detail in *Hydrogeologic Characterization Report*, March 1989, Section 4 1.1.1.

Because DNAPLs are denser than groundwater, and can be retained by aquifer matrix material, DNAPL migration below the water table at the French Limited site is principally controlled by the following factors[3]:

1) Residual saturation of aquifer matrix, i.e., the amount of DNAPL that is retained ("residual DNAPL");
2) Direction and hydraulic gradient of groundwater flow, causing unretained ("free") DNAPL to migrate downgradient;
3) Slope of the base surface of aquifer units, causing free DNAPL that has sunk to the base of the aquifer to migrate down-dip under gravity; and
4) Construction of the sheet-pile flood and migration control wall ("floodwall") in 1989, which, together with inward-gradient pumping from production wells inside the floodwall, should prevent any further migration of groundwater and DNAPL beyond the floodwall.

At the site, the present extent of free and residual DNAPL outside the floodwall likely reflects conditions existing before lagoon remediation and floodwall construction. The extent of free DNAPL within the floodwall probably has been modified by floodwall construction and inward-gradient pumping from wells within the floodwall. DNAPL present beneath the French lagoon has likely migrated downward to the top of the low permeabity zone within and at the base of the S1 and INT units, down the dip slope of these low-permeability zones, and, where influenced by stronger hydraulic gradients near production wells, toward the wells pumping from inside the floodwall. However, the floodwall barrier is likely to prevent wells pumping inside the floodwall drawing free DNAPL back from outside the floodwall.

The main geological features of the site likely to affect DNAPL migration are the C1 and C2 clay units that divide and underlie the upper alluvial zone, respectively. The C1 unit separates the overlying S1 sandy unit from the underlying INT interbedded unit. The C2 unit is a thick clay that underlies the INT unit. The two clay units are probable effective barriers to DNAPL migration. However, as described below, the C1 unit thickness varies across the site and it is absent under part of the site.

2.0 APRIL 1992 INVESTIGATION

The DNAPL investigation in the S1-16 and INT-11 areas was conducted using a cone-penetrometer test (CPT) rig. The rig was used to perform standard CPT soundings which provide detailed vertical engineering and lithologic profiles. This equipment measures the resistance of geologic materials to the penetration of a cone tool as it is pushed into the ground hydraulically. Both the tip resistance and the sleeve or friction resistance to penetration are recorded at intervals of 0.2 feet. Lithologies are defined by the tip and friction resistances and the ratio of these values. Sand units tend to have relatively high tip resistance but low friction resistance compared to clay units. Generally, a friction to tip resistance ratio of greater than 3% indicates clay soils.

A conductivity tool was also run in conjunction with the standard cone-penetrometer tool. The conductivity tool measures the electrical conductance (EC) of the geologic unit, which is a function of both the intergranular fluid and the soil matrix. DNAPLs have very low EC relative to groundwater, particularly high-TDS groundwater. Hence, zones containing a high content of DNAPL in the pore spaces would have a correspondingly lower overall EC than the same soil containing more conductive groundwater. However, if the soil pores contain a mixture of DNAPL and high-TDS groundwater, this

---

[3] Discussed further in Schwille, F., 1988,. *Dense Chlorinated Solvents in Porous and Fractured Media, Model Experiments*, Lewis Publishers, 146 pp. See pp. 5-8 and figure IV.b. for a description of the effects of density, matrix retention, and sloping aquifer base.

effect could be masked. Also, sandy soils have a lower EC relative to clay soils. Therefore, variations in soil type result in variations in EC that must be considered in interpreting CPT-EC profiles.

After running the combination logs, the resistance, ratio, and conductivity profiles were interpreted to determine the depth zones at which DNAPL occurrence was most likely. The CPT rig was then used in soil sampling mode. In this mode, the rig is used to collect narrow-diameter split-spoon soil samples from the selected depth zones, in the same area as the CPT-EC soundings. The soil samples collected are about 1 inch in diameter and 1.5 feet in length. All CPT and soil sampling holes were cemented immediately after completion using cement grout tremied to the bottom of the hole.

During the April 1992 fieldwork, all CPT and soil sampling locations were surveyed for location coordinates and ground surface elevation. Borings and CPTs from earlier investigations at the site were incorporated into the evaluation of the S1-16 and INT-11 areas.

2.1 S1-16 Area

The locations of CPT soundings and soil samples in the S1-16 area are shown on Figure 2. CPT logs are presented in Appendix 2. Interpreted geologic cross sections A-A' and B-B' through the S1-16 area are shown in Figure 3. Both cross sections show the S1 sand unit, underlain by several feet of C1 clay. The relatively thick C1 Clay underlying this area is a probable competent low-permeability barrier to downward DNAPL migration.

Cross sections A-A' and B-B' show the CPT ratio percent profiles arranged in southwest to northeast transects across the investigation area, adjusted to sea level datum. Where available, conductivity curves are superimposed on ratio percent profiles. The ratio percent profiles indicate a thick, fairly uniform sand layer in the S1 interval. Descriptions of samples collected from this interval typically report a fining-upward sequence of coarse, occasionally gravelly sands at the base of the S1, grading to fine to medium sands at the top of the S1. The unit thickens from west to east across the S1-16 area.

Conductivity measurements in the S1 generally increase from top to bottom at individual CPT locations, and also from northeast to southwest in the S1 interval along both cross section traverses. Because the ratio percent profile does not indicate clay layering within the S1, the higher conductivities are likely indicative of higher TDS pore waters. Therefore, the EC pattern probably reflects the presence of high-TDS waters in the S1 unit to the south of French Lagoon and the migration of these denser fluids downward and along the base of the S1 sand.

From the interpreted CPT logs, the elevation of the top of the C1 clay (base of the S1 sand) was determined. Figure 4 shows the structure contours of this surface in the S1-16 area. The structure map was constructed based on CPT soundings performed during the April 1992 fieldwork, and CPT soundings performed during earlier investigations at the site. The top of the C1 generally dips to the east and southeast across the investigation area, away from the French Lagoon source. The elevation of the surface varies from estimated highs of -10.3 feet at C-11 and -11.8 feet at S1-16A to a low of -18.6 at S1-16D (exact elevations of the C1 surface are not available at some locations because the ground surface was not surveyed at the time of the earlier [pre-April 1992] CPT sounding, or was subsequently altered due to addition of fill, etc.). The dip of the C1 surface is approximately 0.13 ft/ft.

The C1 Clay isopach contour map (Figure 5) shows the thickness of the C1 unit beneath the S1-16 area. Figure 5 shows that the C1 clay generally exceeds 3 feet in thickness in this area, and thickens to the east and north. The C1 also thickens to the south outside the area of investigation. No data is available on the C1 thickness under French Lagoon.

Figure 6 summarizes data obtained regarding DNAPL occurrence in the S1 interval in the S1-16 area. This figure includes data obtained before and during the April 1992 investigation. These include analyses of soil samples collected from S1-17 (included in Table 1), and field observations of oily stains, residues, odors, etc. made during drilling (observations at S1-16A, S1-16C, S1-16G, and S1-16H are included in Table 2). Also shown in Figure 6 are organic vapor meter (OVM) readings made during drilling, and sites where conductivity anomalies (zones of relatively lower EC) were noted.

Inside the flood wall, CPT-EC sounding S1-16A was conducted near well S1-16 where DNAPL was detected. A conductivity anomaly close to the base of the S1 unit can be seen in Figure 3. Fluid samples retrieved from this interval using a small bailer lowered through the cone rods did not contain any DNAPL. However, during cementing of the CPT hole, a black oily mixture was observed in the cement returns, indicating that DNAPL had been present in the hole. Due to the high viscosity of DNAPL, it is difficult to retrieve by bailing. A second CPT-EC sounding conducted inside the floodwall at location S1-16B, east of the lagoon, did not indicate a low-conductivity zone, and no discoloration of the cement was noted during grouting.

Outside the floodwall, cone-penetrometer profiles were conducted at approximately 25 ft spacing in the vicinity of well S1-16. EC anomalies were noted at S1-16D and S1-16E. Because the top of the C1 unit slopes to the southeast, a number of split-spoon samples were attempted in the area outside the floodwall and southeast of S1-16. Unfortunately, attempts to retrieve soil samples at the S1/C1 interface were largely unsuccessful. The sampler apparently could not retain the fairly coarse-grained material typical of the base of the S1 unit. The only successful soil retrievals were at locations S1-16G and S1-16H. The soil samples appeared to contain residual DNAPL at the bottom of the S1.

Mainly because the sampling of the lower S1 material was not successful, further work is required in this area to clearly define the extent of DNAPL occurrence. Outside the floodwall the extent of DNAPL is defined to the northeast at S1-16H, and to the southwest at S1-16F. However, it is not defined to the southeast. The northwestern extent of this DNAPL is not defined but is likely the lagoon source.

2.2 INT-11 Area

The locations of CPT-EC soundings and soil samples in the INT-11 area are shown on Figure 7. CPT logs are presented in Appendix 3. An interpreted east-west geologic cross section through the INT-11 area, section C-C', prepared in the same way as sections A-A' and B-B', is shown in Figure 8. It shows the S1 sand unit overlying the INT interval, separated from it by a variable thickness of C1 clay. The C1 clay thickness decreases from 6.6 feet at INT-64 to 1 foot or less at INT-10 , S1-11, and INT-63, and continues to thin to the west. The C1 clay isopach contour map (Figure 9) shows the thickness of the C1 unit beneath the INT-11 area. Figure 9 shows that the C1 clay is thin (< 1 foot) to the north and west of the INT-11 area, and is absent west of INT-10. The thinning in the C1 clay appears to be due to erosion and downcutting during deposition of the S1 sand. Clearly, where the C1 clay is thin or absent it is unlikely to act as a barrier to downward DNAPL migration.

It is also possible that abandoned well REI-6-2 (see Figure 12 for location) could have acted as an additional vertical conduit for DNAPL. The construction details of REI-6-2 are presented in Appendix 4 and are shown projected onto section C-C' in Figure 8. The projected top of the water intake interval (comprising the screen and filter pack) is close to the top of the C1 clay. Although the boring log indicates 4 feet of clay at this location, adjacent CPT soundings show a much thinner clay. Therefore, it is possible that the water intake interval could connect the S1 and INT units. Because it is no longer in use, this well should be properly plugged and abandoned during future drilling work at the site.

From the interpreted CPT logs, the elevation of the top of the C1 clay (base of the S1 sand) was determined. Figure 10 shows the structure contours of this surface in the INT-11 area. The top of the C1 clay forms a low area under and south of the French Lagoon in the north central portion of the INT-11 area. This low corresponds with the area of thinning in the C1 clay described above, which is consistent with the removal of the C1 clay being due to erosion and downcutting during deposition of the S1 sand. Therefore, the top of the C1 generally dips inward toward the S1-11 and INT-11 locations, which would tend to cause DNAPL, if present, to accumulate near S1-11 and INT-11, in the area where the C1 clay is thin. The elevation of the surface varies from estimated highs of -10.8 feet at INT-64, and -13 feet between INT-10 and S1-23, to lows of -17.6 at INT-11 and -18.6 at S1-11 (exact elevations of the C1 surface are not available at some locations because the ground surface was not surveyed at the time of the earlier [pre-April 1992] CPT sounding, or was subsequently altered due to addition of fill, etc.). The inward dip of the C1 surface is approximately 0.11 ft/ft.

Where the C1 clay is thin or absent, and therefore unlikely to act as a barrier to downward migration, DNAPLs would tend to migrate downward to the top of the C2 clay (Beaumount Formation). The elevation of the top of the C2 clay (base of the INT interval) is shown on Figure 11. Figure 11 shows that the C2 clay in this area mainly dips to the east-northeast, from an estimated high of -31.5 feet at INT-63 to a low of -36.1 feet in INT-64. This is the main direction toward which DNAPL reaching the top of the C2 in this area would be expected to migrate. The dip of the C2 surface is approximately 0.04 ft/ft. To the west of the INT-11 area, the C2 surface dips at a similar gradient to the west-southwest. from a ridge between C-3 and INT-63.

Figure 12 summarizes data obtained regarding DNAPL occurrence in the INT-11 area. This figure includes data obtained before and during the April 1992 investigation. These include TOC and TPH analyses of soil samples collected from INT-10 and INT-64 (included in Table 1), and field observations of oily stains, residues, odors, etc. made during CPT soil sampling (observations at INT-11A through INT-11G are included in Table 2). VOC analyses of soil samples collected from INT-64 are presented in Table 3. Analyses of soil samples collected at INT-11B and INT-11C are included in Appendix 5 and summarized in Table 4. Also shown in Figure 12 are organic vapor meter (OVM) readings made during drilling, and sites where conductivity anomalies (zones of relatively lower EC) were noted.

A CPT-EC sounding (INT-11A) was conducted near the INT-11 well where DNAPL is known to exist. A conductivity anomaly close to the base of the INT unit at INT-11A can be seen in Figure 8. The conductivity profile indicates a zone of relatively lower conductivity close to the base of the INT unit just above the underlying C2 Clay. Fluid samples retrieved through the cone rods using a small bailer from this interval did not show any DNAPL. As indicated above, it is difficult to retrieve the higher viscosity free-phase fluids by this method. However, during cementing of the CPT hole, a black oily mixture was observed in the cement returns indicating the presence of DNAPL in this hole. Field observations made during CPT soil sampling also suggested possible free DNAPL at INT-11B through F. Soil samples obtained from the 48 to 49 ft depth interval at these locations showed evidence of DNAPL residual. The soil samples left an oily residue on the core barrel and when squeezed the soils released a watery oily fluid. However, free DNAPL in the pore spaces of these soil samples was not evident.

Field observations made during drilling indicated residual DNAPL at INT-10. However, soil samples collected from INT-10 did not contain detectable TOC. VOC analyses were not performed on these samples. INT-10 may represent an area of residual DNAPL. Soil samples collected from INT-64 did not contain detectable TPH and did not show staining or free DNAPL. However, soil samples collected from INT-64 (Table 3) showed high concentrations of VOCs, particularly in the lower 10 feet, i.e., above the C2 clay. VOCs detected include methylene chloride, (5.1 ppm), 1,2-dichloroethane (4.4 ppm), acetone (3.4 ppm), carbon disulfide (2.8 ppm), and chloroform (1 ppm). These high concentrations of VOCs and their distribution with depth suggest that INT-64 may be at the fringe of DNAPL migration from the INT-11 area.

Soil samples were collected from INT-11B and INT-11C locations (Table 4). Including tentatively identified compounds and compounds identified below the detection limit, the soil samples from INT-11B contained 4.7 to 8.4 percent VOCs and 6.1 percent SVOCs; and from INT-11C, 3.2 to 3.3 percent VOCs and 2 percent SVOCs. The major VOC components are chloroform, 1,2-DCE, 1,2-DCA, carbon tetrachloride, and PCE.

The field observations and laboratory data presented support the conclusion that DNAPL from the lagoon area accumulated at the base of the S1 sand in the S1-11/INT-11 area, migrated downward through the thin or missing C1 clay (and, potentially, abandoned well REI-6-1) to the base of the INT interval, and then migrated down the dip of the C2 clay, mainly to the east-northeast. DNAPL residuals have been observed 10-15 feet to the south of INT-11 and are present over much of the area bounded by the INT-11 well, the floodgate, the sheetpile floodwall and the property fence. CPT soundings could not be completed south of the property boundary due to access difficulties. The extent of DNAPL appears to be defined to the east by its absence at S1-22, DB-19, and INT-11G, and to the southwest by its absence at DB-18. However, it is not defined to the south of INT-11.

At INT-10, a less well-defined occurrence of DNAPL is indicated only by staining and odor (Figure 12). In this area, the C2 surface dips toward the west-southwest (Figure 11). DNAPLs probably entered the INT interval in the same manner as described above and followed the local structural gradient at the base of the INT interval toward INT-10 and DB-17.

2.3 Area Inside Floodwall

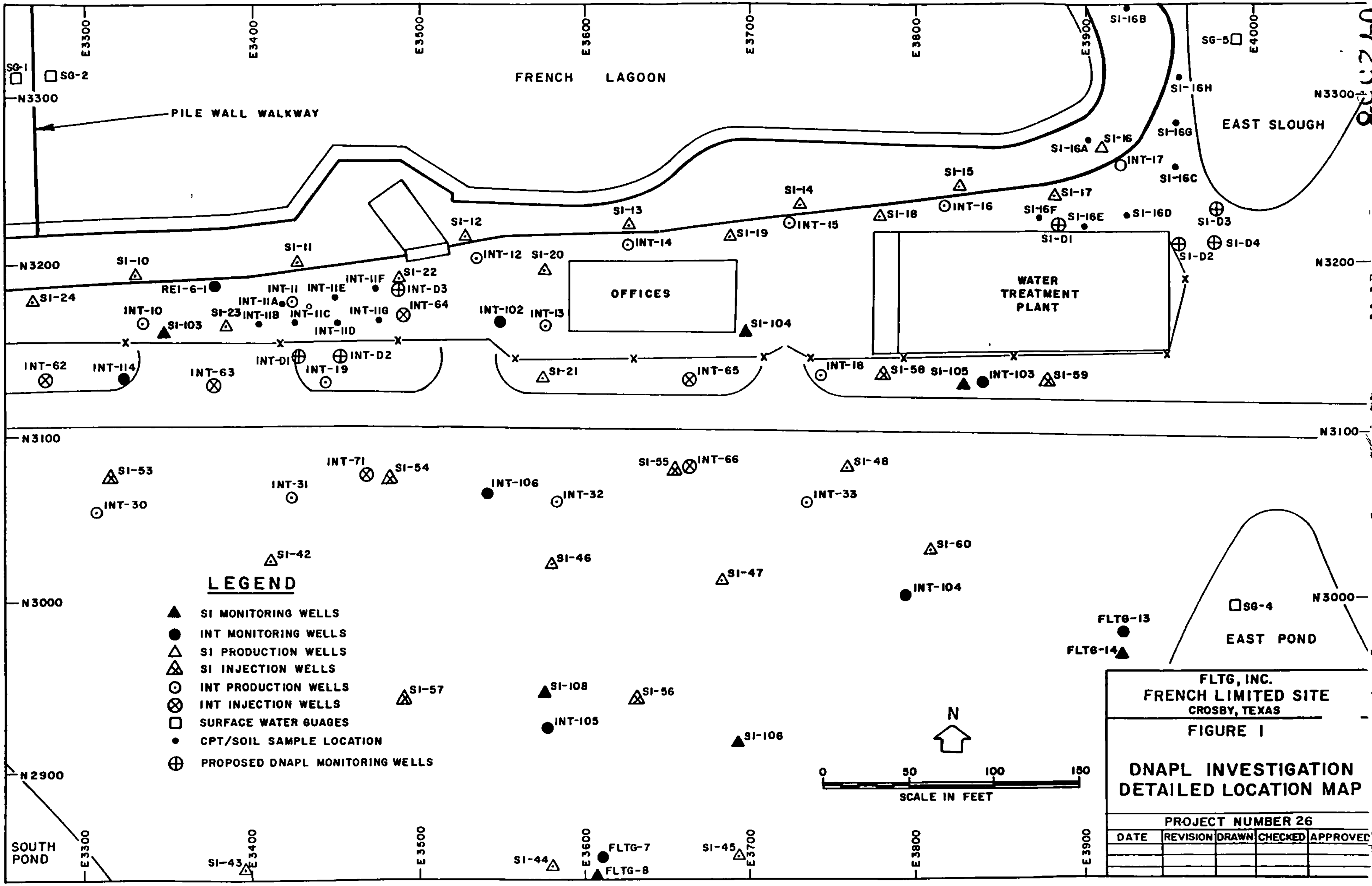
Additional observations were made during operation of the production well system after the April 1992 field investigation was complete. Since the April 1992 investigation, DNAPL has been reported at more wells inside the flood wall. In June 1992, DNAPL was observed in clogged well-head flow meters, pressure gauges, or bends in piping further down the system, at wells S1-4, S1-13, and S1-14. Samples from S1-4, S1-13, and S1-14 have been submitted for analysis for VOCs, SVOCs, TOC, and TOX. The detection of DNAPL at these wells is consistent with the conceptual model of DNAPL migration presented above: operation of the production wells inside the floodwall has pulled DNAPL previously underlying the lagoon toward those wells.

3.0 SUMMARY AND CONCLUSIONS

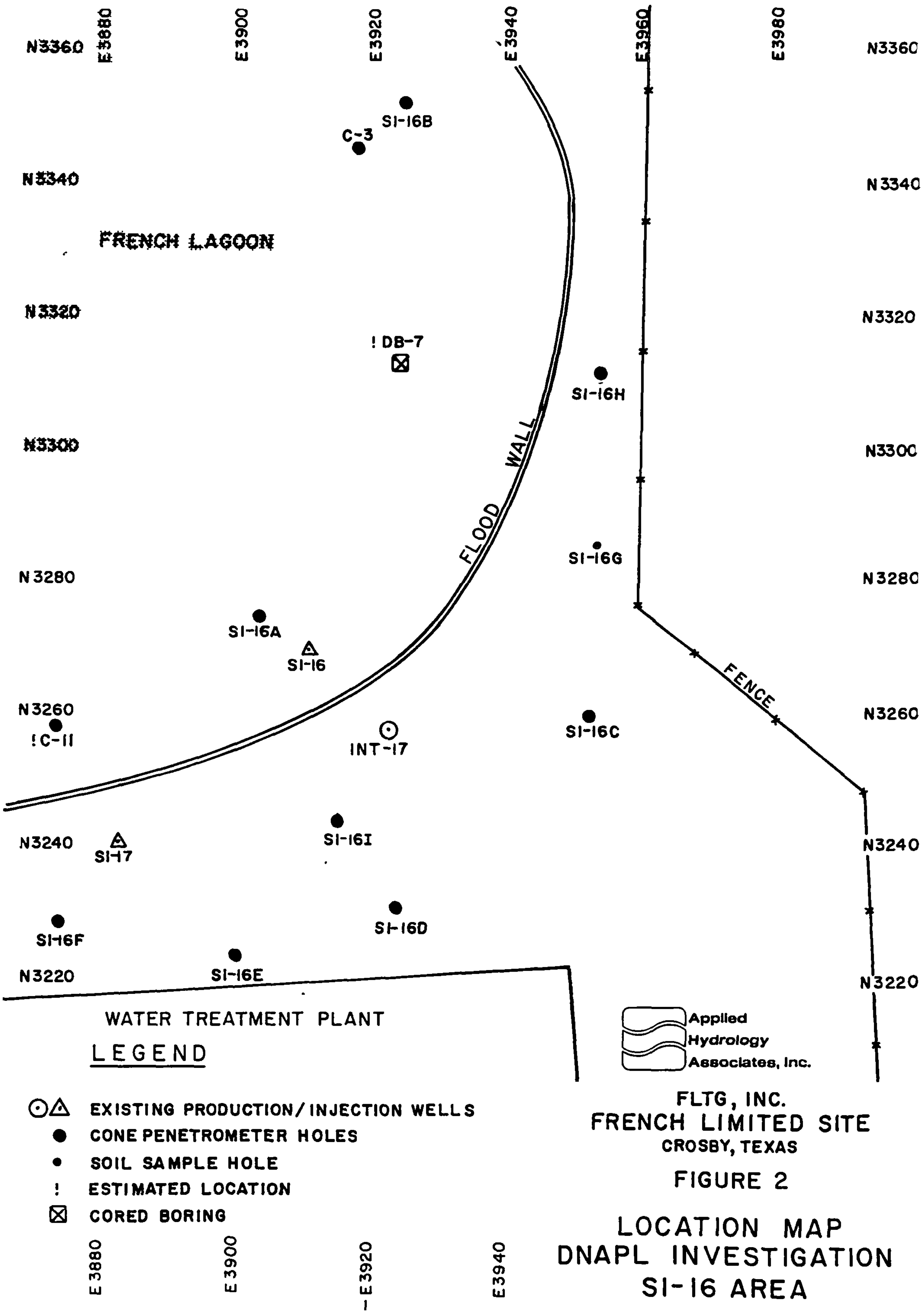
1. The April, 1992 field investigations combined with data from earlier investigations, confirms the presence of DNAPL residuals in soils outside the floodwall in the S1-16 and INT-11 areas. DNAPL appears to be concentrated at the base of the S1 unit in the S1- 16 area, and at the base of the INT unit in the INT-11 area.

2. The ocurrence and distribution of observed DNAPL is consistent with DNAPL migration controlled primarily by the structural configuration of the C1 and C2 clay units.

3. More detailed soil sampling needs to be performed in the S1-16 and INT-11 areas to fully define DNAPL distribution in these areas. Details of proposed soil sampling will be presented in the *DNAPL Additional Investigation Work Plan.*


FRENCH LAGOON
PILE WALL WALKWAY
EAST SLOUGH
OFFICES
WATER TREATMENT PLANT
EAST POND
SOUTH POND
LEGEND
SI MONITORING WELLS
INT MONITORING WELLS
SI PRODUCTION WELLS
SI INJECTION WELLS
INT PRODUCTION WELLS
INT INJECTION WELLS
SURFACE WATER GUAGES
CPT/SOIL SAMPLE LOCATION
PROPOSED DNAPL MONITORING WELLS
N
0 50 100 150
SCALE IN FEET
FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS
FIGURE 1
DNAPL INVESTIGATION
DETAILED LOCATION MAP
PROJECT NUMBER 26
DATE
REVISION
DRAWN
CHECKED
APPROVED
072558

072559

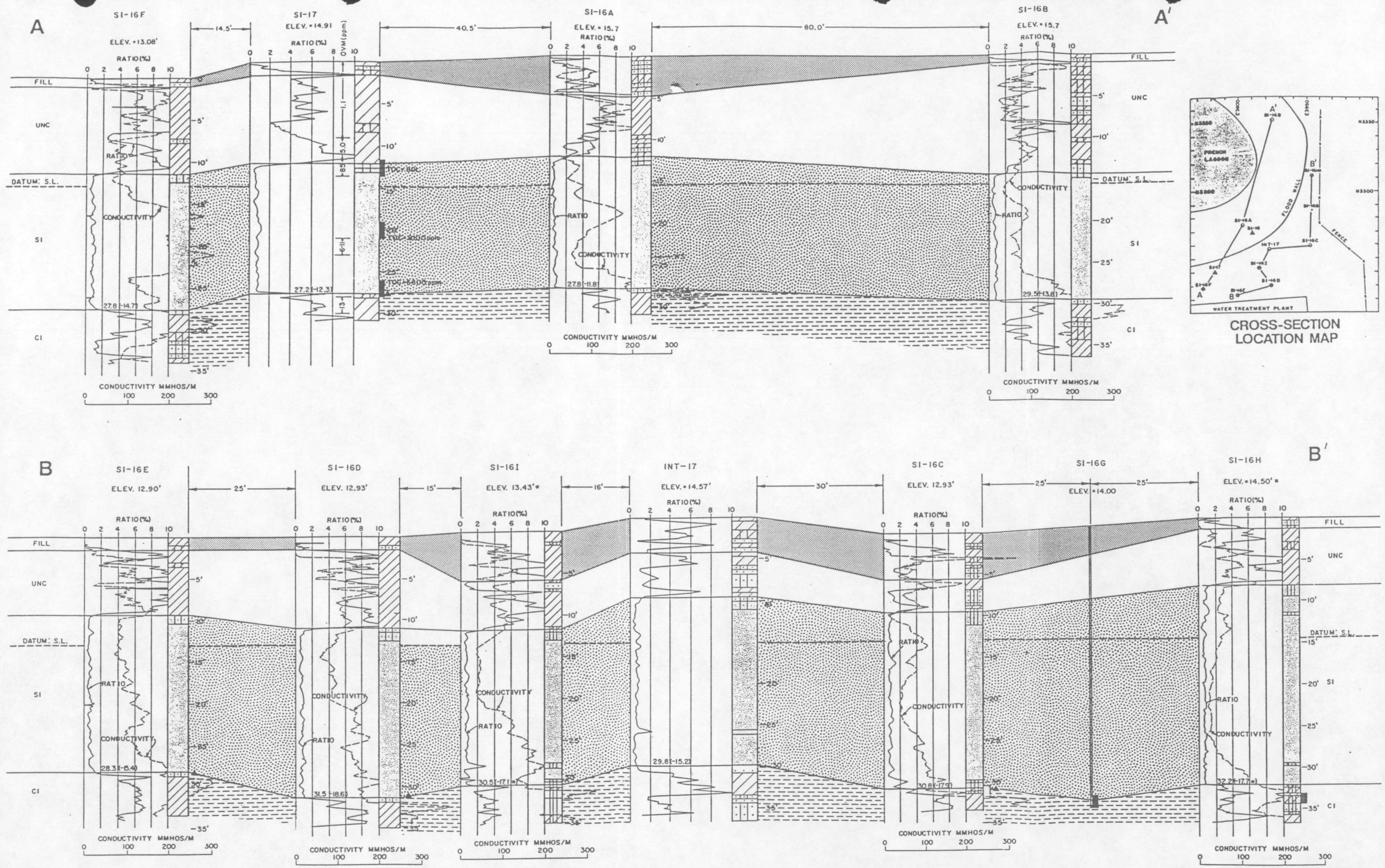


FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

FIGURE 2

LOCATION MAP
DNAPL INVESTIGATION
SI-16 AREA

072560



LEGEND

TOC = TOTAL ORGANIC CARBON (MEASUREMENTS IN ppm)
OVM = ORGANIC VAPOR MONITOR (READINGS IN ppm)

LEGEND

WS — WATER SAMPLE
RECOVERED SOIL SAMPLE
LOST SOIL SAMPLE
▲ INDICATION OF DNAPL

0 10 20 30 40
HORIZONTAL SCALE IN FEET

0 5 10 15 20
VERTICAL SCALE IN FEET

FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

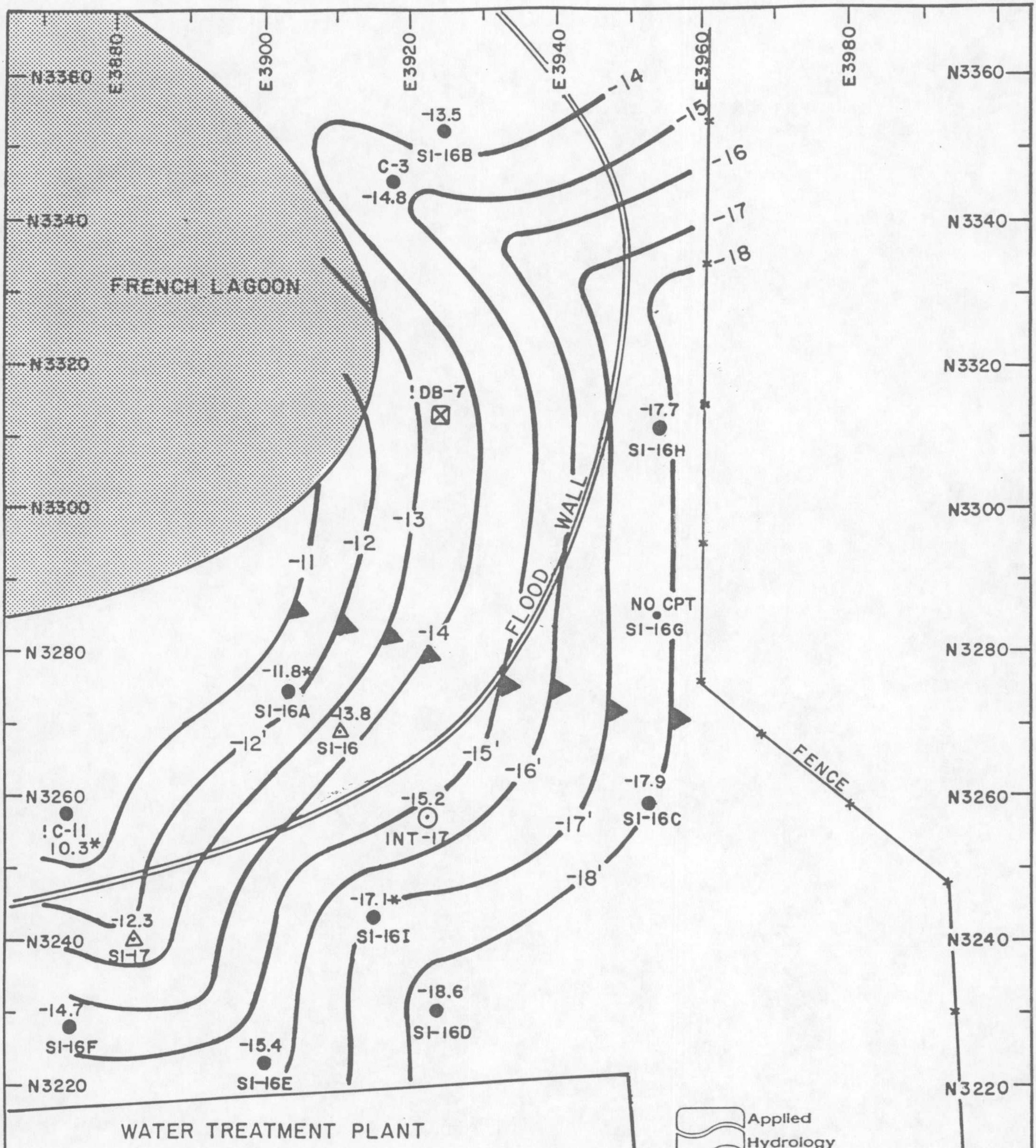
FIGURE 3
CROSS-SECTIONS A-A′ & B-B′
DNAPL INVESTIGATION
S1-16 AREA

Applied Hydrology Associates, Inc.

PROJECT NUMBER 26

DATE	REVISION	DRAWN	CHECKED	APPROVED
5/20/92	0	SGS	SRS	

072561



Applied Hydrology Associates, Inc.

LEGEND

- * ESTIMATED GROUND ELEVATION
- ⊙△ EXISTING PRODUCTION/INJECTION WELLS
- ● CONE PENETROMETER HOLES
- • SOIL SAMPLE HOLE
- ! ESTIMATED LOCATION
- ⊠ CORED BORING

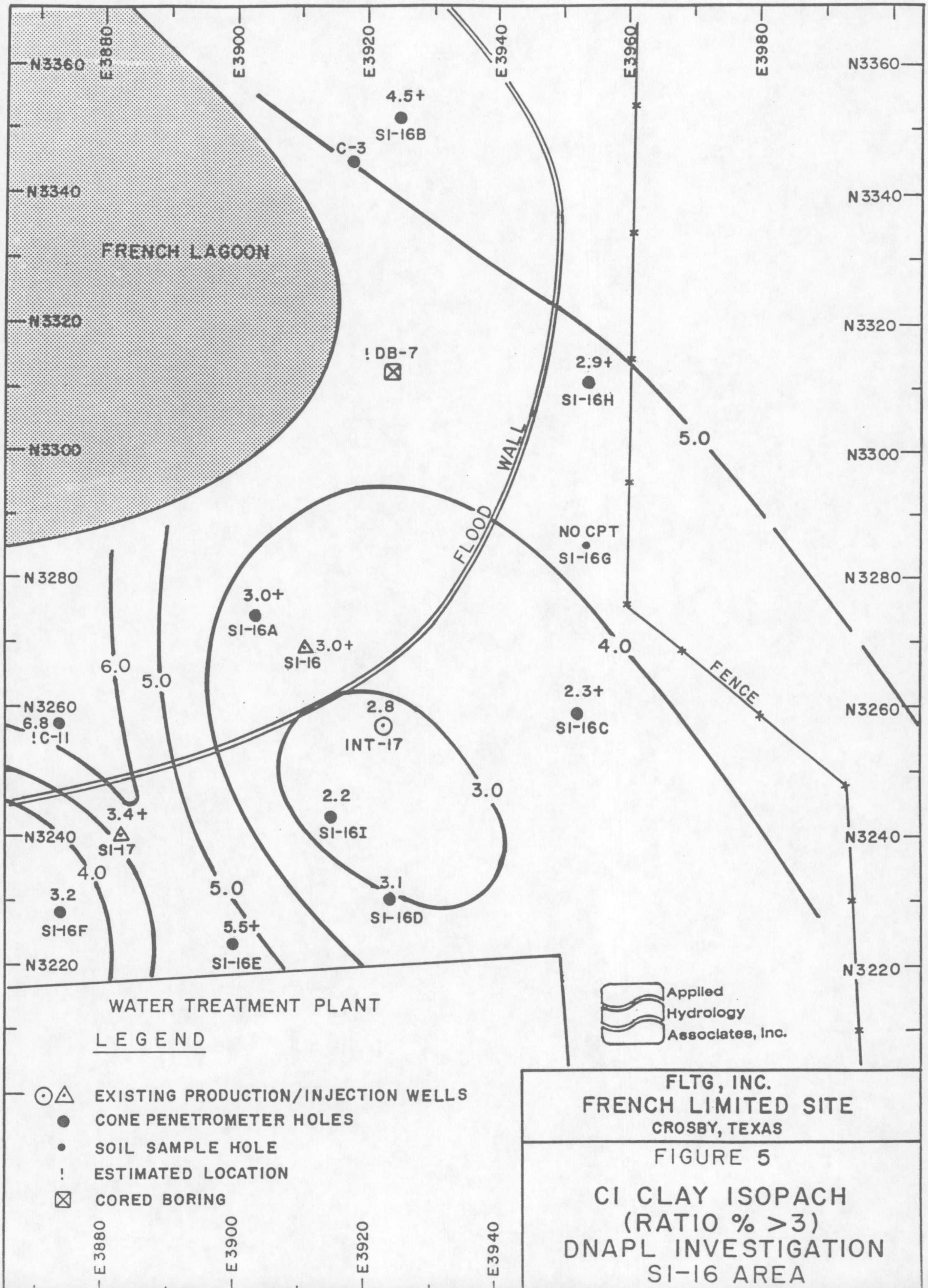
E3880 E3900 E3920 E3940

FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

FIGURE 4

STRUCTURE
ON THE CI INTERVAL
DNAPL INVESTIGATION
SI-16 AREA

072562

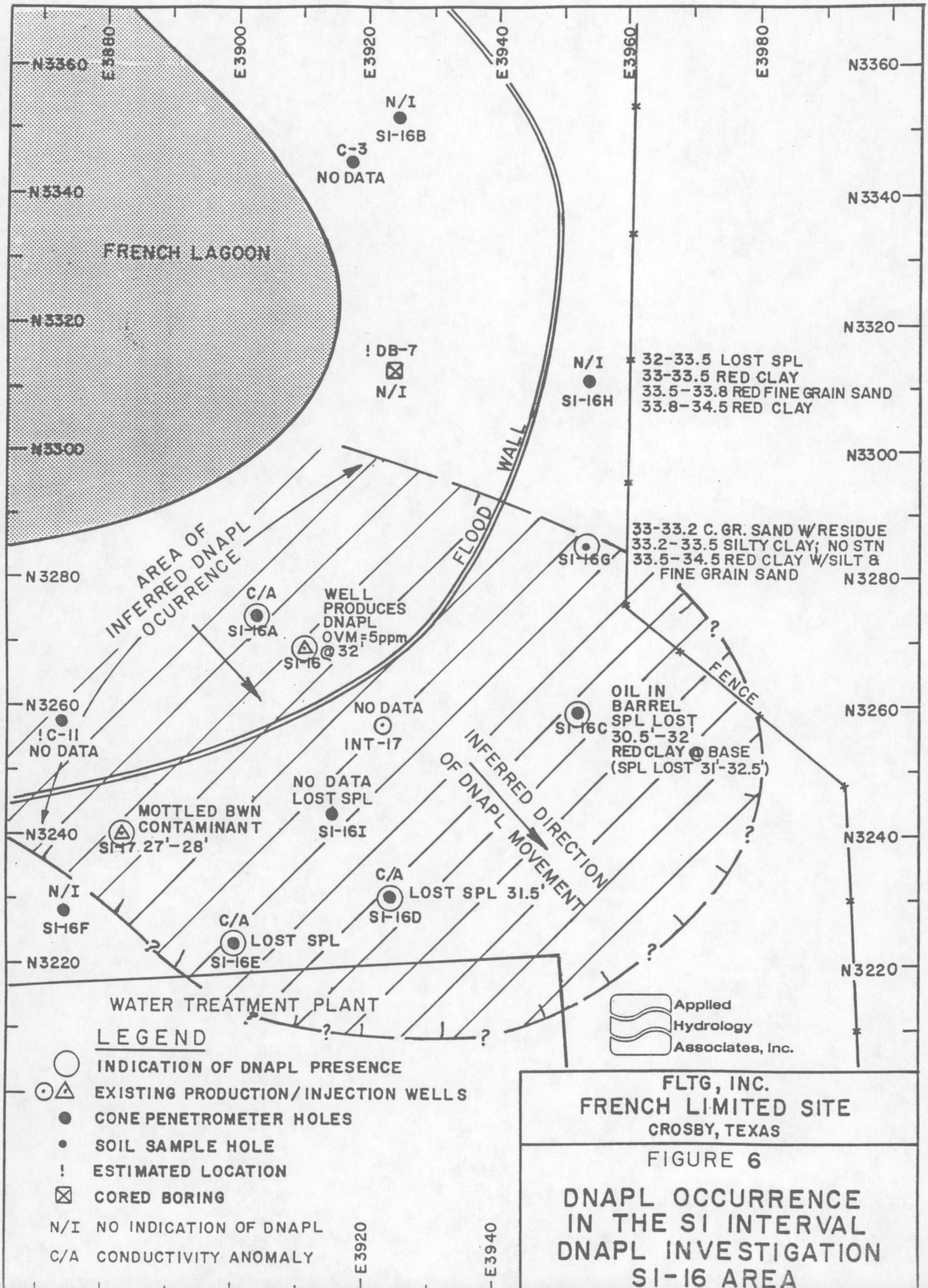


FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

FIGURE 5

CI CLAY ISOPACH
(RATIO % >3)
DNAPL INVESTIGATION
SI-16 AREA

072563



LEGEND

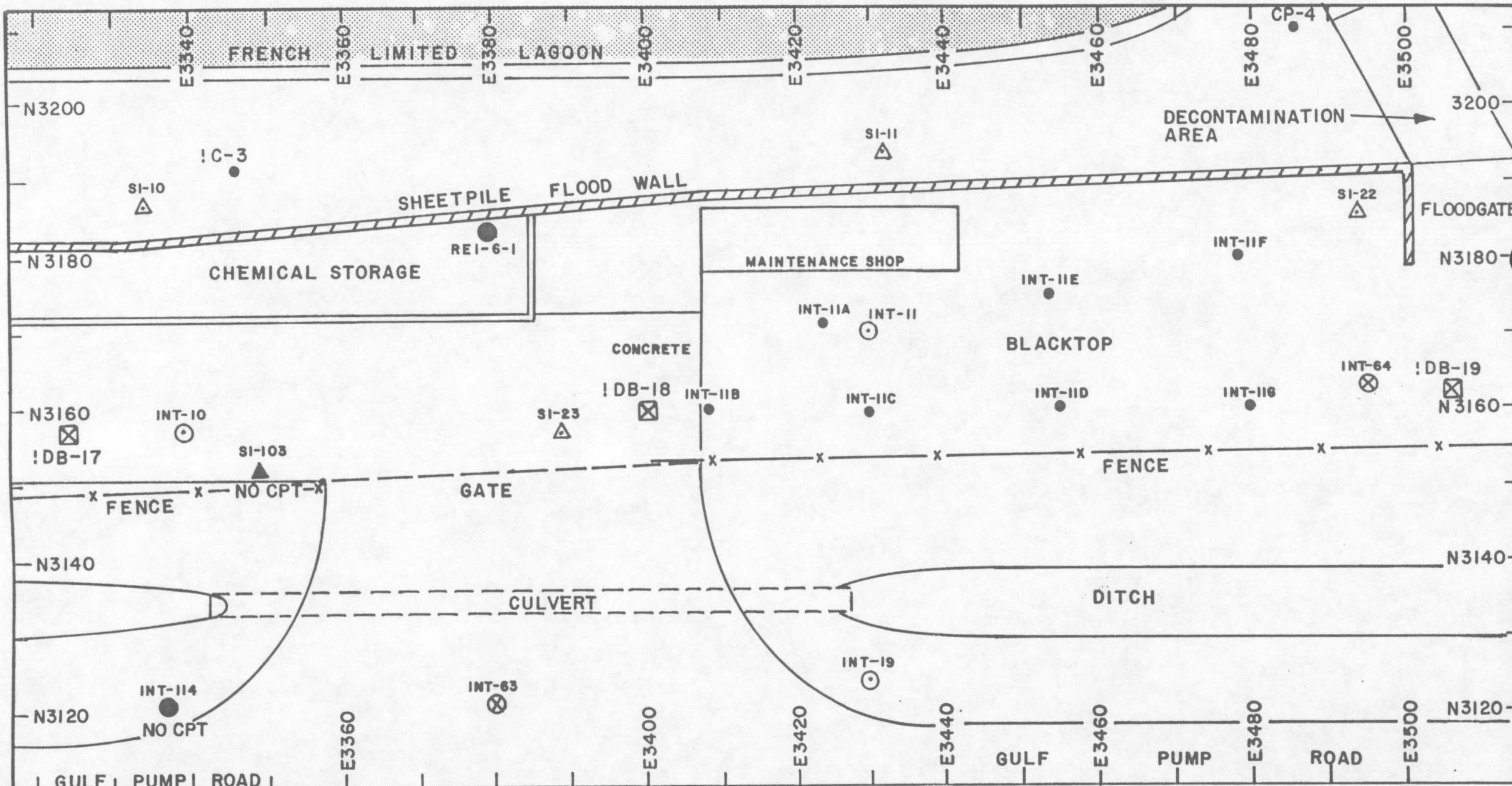
- INDICATION OF DNAPL PRESENCE
- EXISTING PRODUCTION/INJECTION WELLS
- CONE PENETROMETER HOLES
- SOIL SAMPLE HOLE
- ! ESTIMATED LOCATION
- CORED BORING
- N/I NO INDICATION OF DNAPL
- C/A CONDUCTIVITY ANOMALY

FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

FIGURE 6

DNAPL OCCURRENCE IN THE SI INTERVAL DNAPL INVESTIGATION SI-16 AREA

0725564



LEGEND

N/P INT NOT PENETRATED

⊗⊙△ EXISTING PRODUCTION/INJECTION WELLS

▲● EXISTING MONITORING WELLS

● CONE PENETROMETER HOLES

! ESTIMATED LOCATION

⊠ CORED BORING

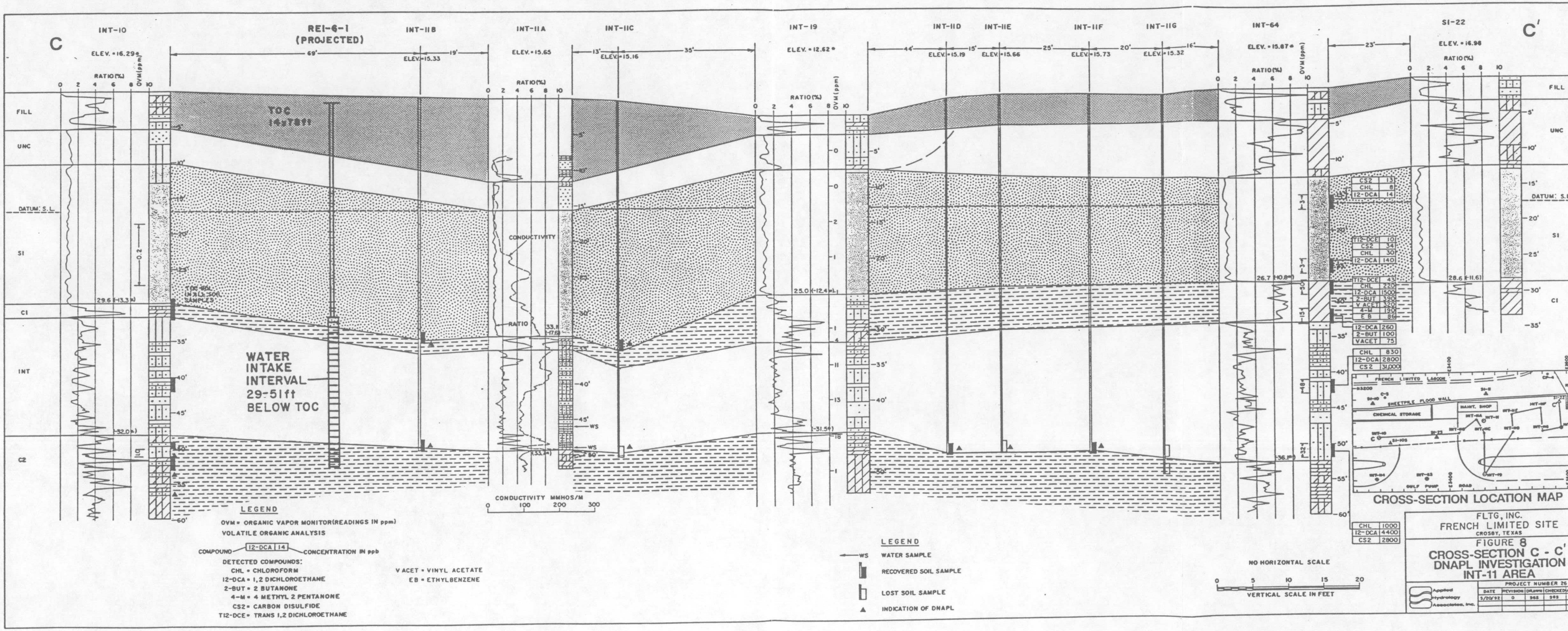
N/I NO INDICATION OF DNAPL

FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

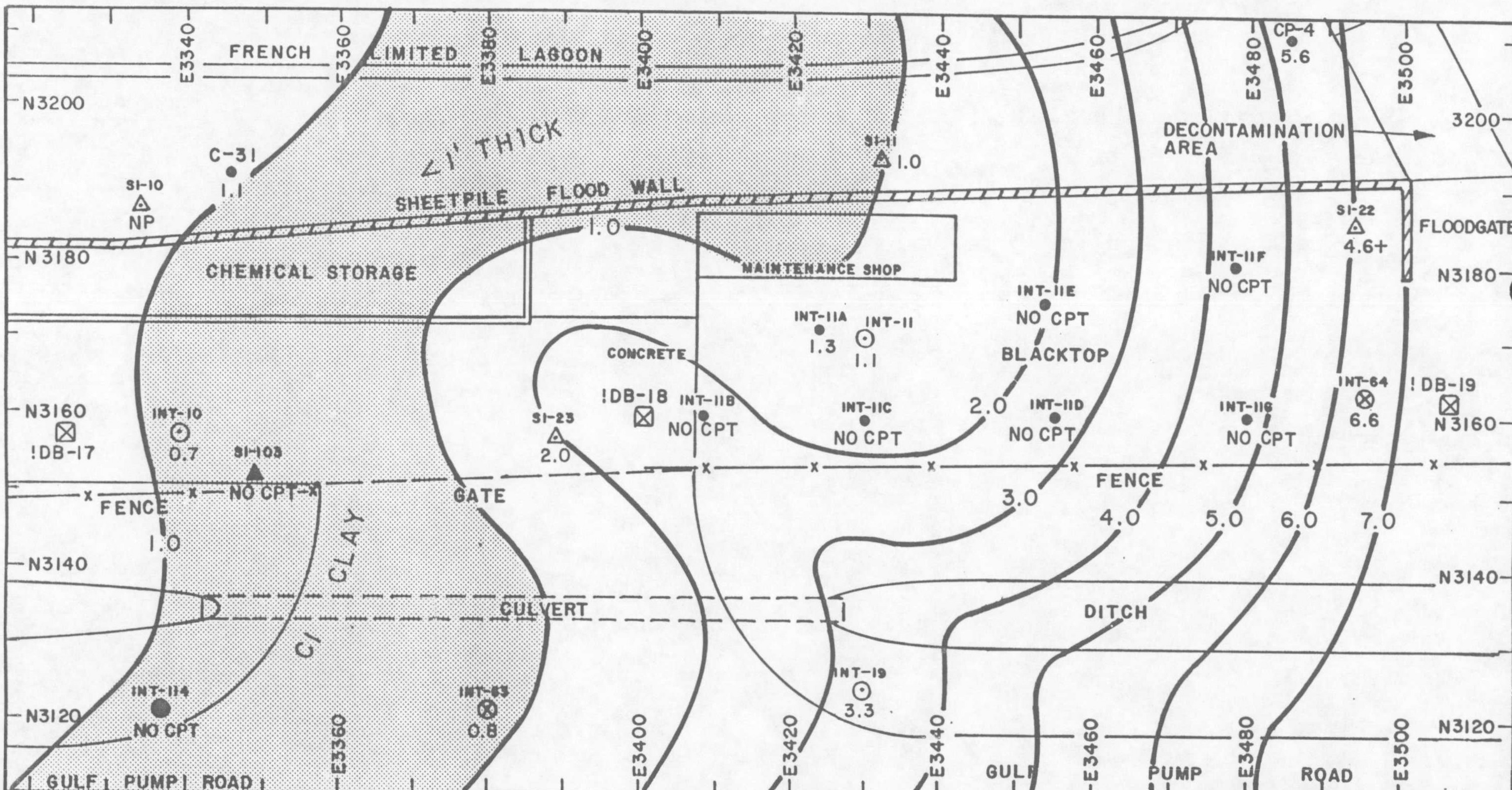
FIGURE 7

LOCATION MAP
DNAPL INVESTIGATION
INT-11 AREA

072565


C
C'
INT-10
ELEV. = 16.29±
REI-6-1
(PROJECTED)
INT-11B
ELEV. = 15.33
INT-11A
ELEV. = 15.65
INT-11C
ELEV. = 15.16
INT-19
ELEV. = 12.62±
INT-11D
ELEV. = 15.19
INT-11E
ELEV. = 15.66
INT-11F
ELEV. = 15.73
INT-11G
ELEV. = 15.32
INT-64
ELEV. = 15.87±
SI-22
ELEV. = 16.98
RATIO(%)
OVM(ppm)
FILL
UNC
DATUM: S.L.
SI
CI
INT
C2
TOC
14.78 ft
WATER
INTAKE
INTERVAL
29-51 ft
BELOW TOC
CONDUCTIVITY
RATIO
CONDUCTIVITY MMHOS/M
0 100 200 300
CS2 13
CHL 8
12-DCA 14
T12-DCE 10
CS2 34
CHL 30
12-DCA 140
T12-DCE 43
CHL 220
12-DCA 1500
2-BUT 390
V ACET 320
4-M 190
E B 86
12-DCA 260
2-BUT 100
VACET 75
CHL 830
12-DCA 2800
CS2 31,000
CHL 1000
12-DCA 4400
CS2 2800
FRENCH LIMITED LAGOON
SHEETPILE FLOOD WALL
CHEMICAL STORAGE
MAINT. SHOP
GULF PUMP ROAD
CROSS-SECTION LOCATION MAP
LEGEND
OVM = ORGANIC VAPOR MONITOR(READINGS IN ppm)
VOLATILE ORGANIC ANALYSIS
COMPOUND 12-DCA 14 CONCENTRATION IN ppb
DETECTED COMPOUNDS:
CHL = CHLOROFORM
12-DCA = 1,2 DICHLOROETHANE
2-BUT = 2 BUTANONE
4-M = 4 METHYL 2 PENTANONE
CS2 = CARBON DISULFIDE
T12-DCE = TRANS 1,2 DICHLOROETHANE
V ACET = VINYL ACETATE
EB = ETHYLBENZENE
LEGEND
WS WATER SAMPLE
RECOVERED SOIL SAMPLE
LOST SOIL SAMPLE
INDICATION OF DNAPL
NO HORIZONTAL SCALE
0 5 10 15 20
VERTICAL SCALE IN FEET
FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS
FIGURE 8
CROSS-SECTION C - C'
DNAPL INVESTIGATION
INT-11 AREA
Applied Hydrology Associates, Inc.
PROJECT NUMBER 26
DATE 5/20/92
REVISION 0

0725666



LEGEND

⊗⊙△ EXISTING PRODUCTION/INJECTION WELLS

▲● EXISTING MONITORING WELLS

• CONE PENETROMETER HOLES

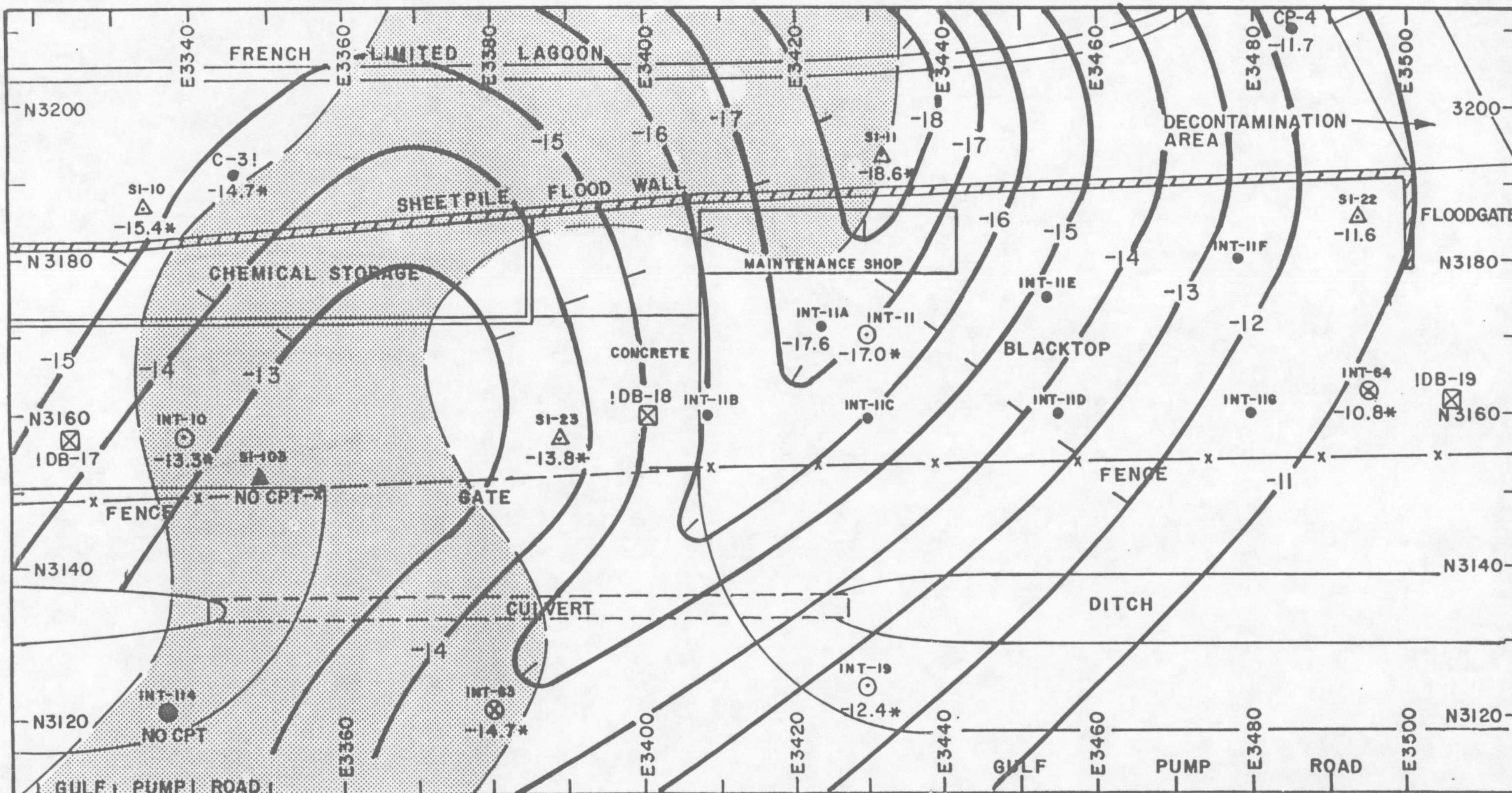
NP CI NOT PENETRATED

! ESTIMATED LOCATION

⊠ CORED BORING

FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

FIGURE 9
CI CLAY ISOPACH
(RATIO % >3)
DNAPL INVESTIGATION
INT-11 AREA



LEGEND

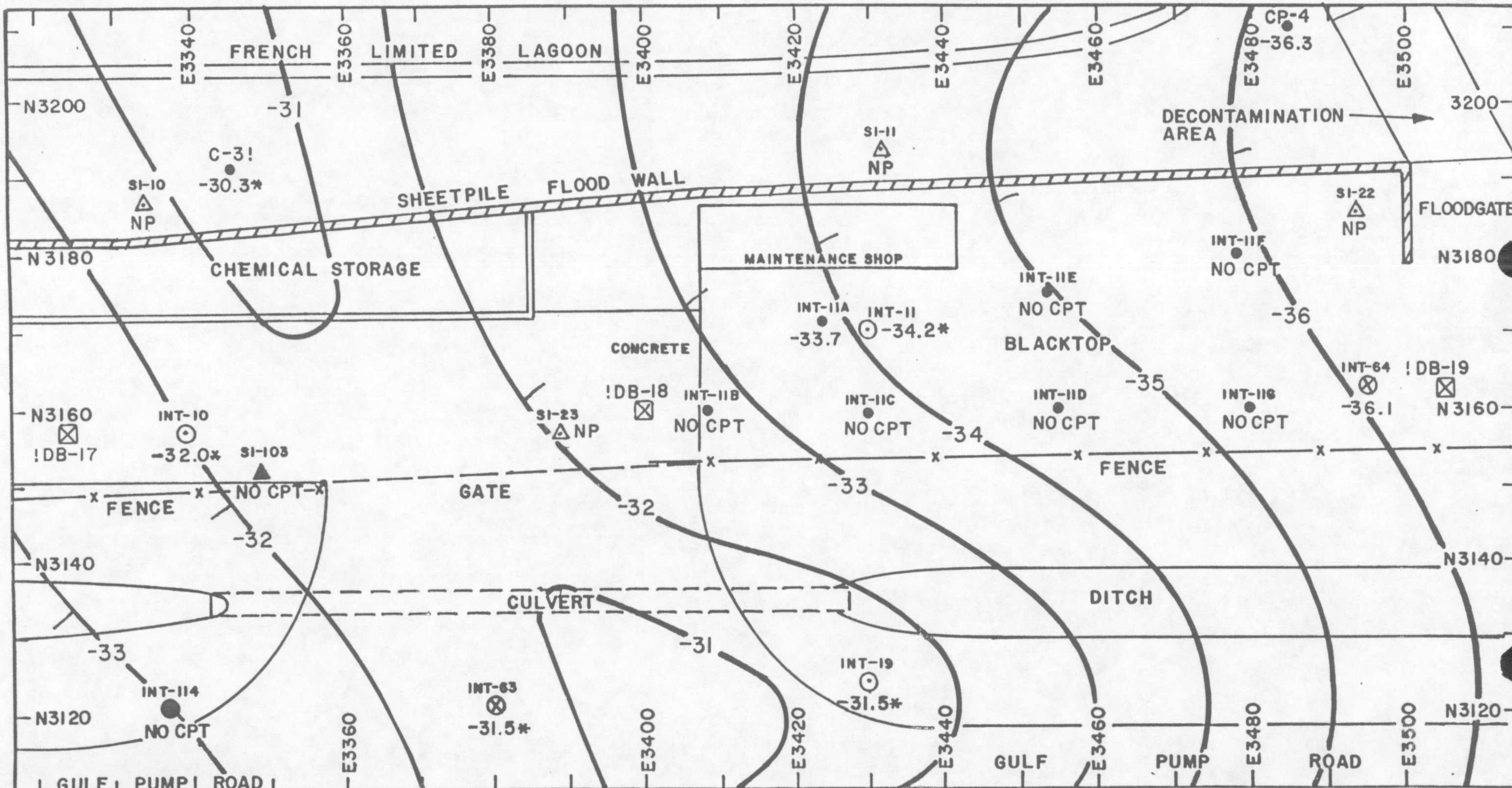
- * ESTIMATED GROUND LEVEL
- ⊗⊙△ EXISTING PRODUCTION/INJECTION WELLS
- ▲● EXISTING MONITORING WELLS
- • CONE PENETROMETER HOLES
- ! ESTIMATED LOCATION
- ⊠ CORED BORING
- (shaded) CI CLAY < 1' THICK

FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

FIGURE 10
STRUCTURE
ON THE CI INTERVAL
DNAPL INVESTIGATION
INT-11 AREA

0725567

072568



LEGEND

* ESTIMATED GROUND LEVEL

⊗⊙△ EXISTING PRODUCTION/INJECTION WELLS

▲● EXISTING MONITORING WELLS

• CONE PENETROMETER HOLES

NP C2 NOT PENETRATED

! ESTIMATED LOCATION

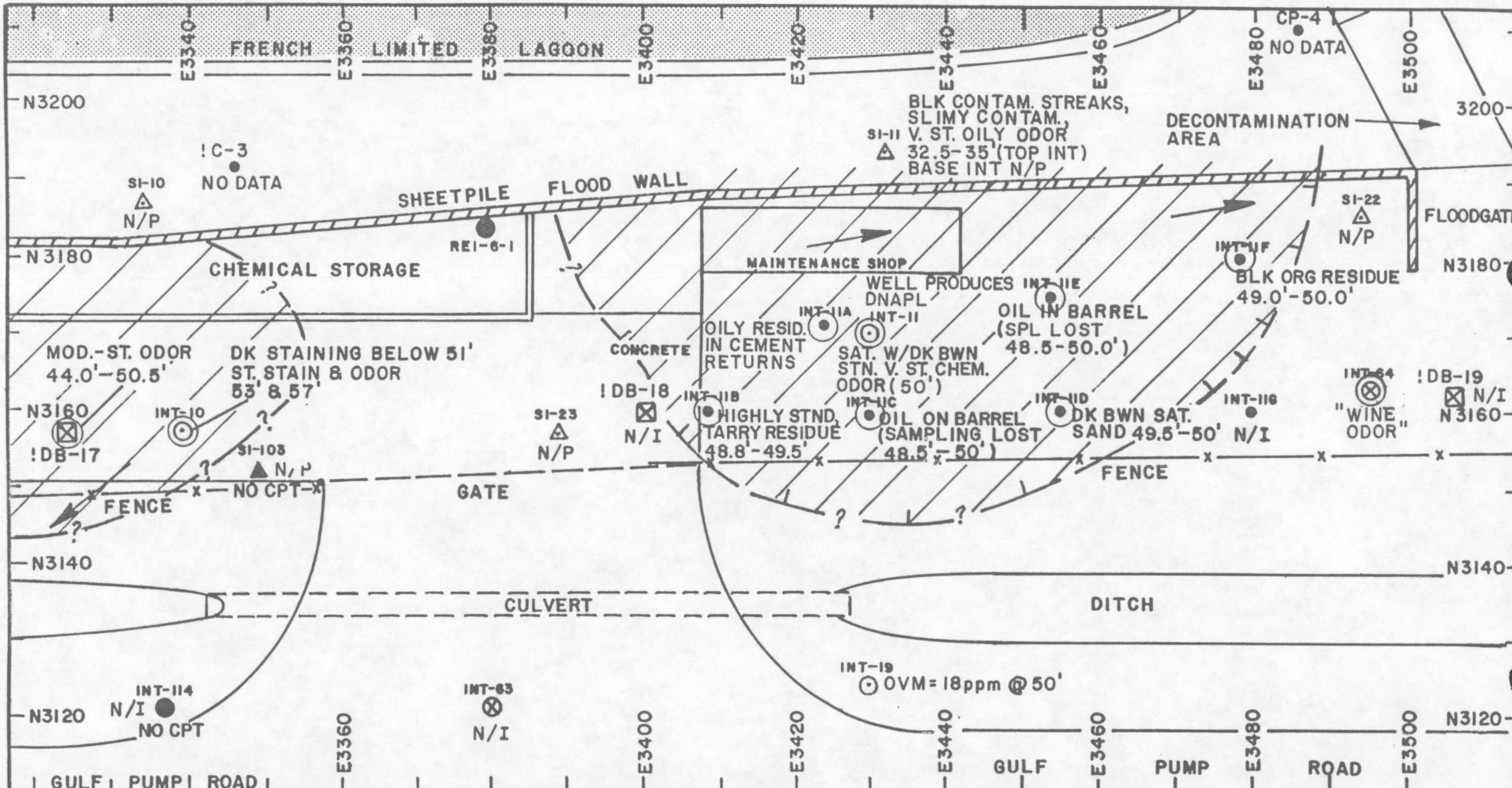
⊠ CORED BORING

FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

FIGURE 11

STRUCTURE ON THE C2 INTERVAL DNAPL INVESTIGATION INT-11 AREA

072569



LEGEND

N/P	INT NOT PENETRATED
⊗⊙△	EXISTING PRODUCTION/INJECTION WELLS
▲●	EXISTING MONITORING WELLS
•	CONE PENETROMETER HOLES
!	ESTIMATED LOCATION
⊠	CORED BORING
N/I	NO INDICATION OF DNAPL
○	PRESENCE OF DNAPL INDICATED
⋌	INFERRED EXTENT OF DNAPL PLUME
↗	INFERRED DIRECTION OF DNAPL MOVEMENT

FLTG, INC.
FRENCH LIMITED SITE
CROSBY, TEXAS

FIGURE 12

DNAPL OCCURRENCE IN THE INT INTERVAL DNAPL INVESTIGATION INT-11 AREA

072570

TABLE 1

SUMMARY OF SOIL SAMPLE ANALYSES
S1-16 AND INT-11 AREAS

WELL	Depth	TOC(ppm)	TPH(ppm)
INT-10	29-30'	BDL	NA
	30-31.5'	BDL	NA
	41-42'	BDL	NA
	50-51'	BDL	NA
	52-53'	BDL	NA
S1-17	11.5-13.5'	BDL	NA
	19-21'	8100	NA
	26-28' (27')	6600	NA
INT-64	15-17'	NA	BDL
	24-26'	NA	BDL
	27-29'	NA	BDL
	31-32'	NA	BDL
	41-43'	NA	BDL
	50-52'	NA	BDL

TABLE 2

SAMPLE DESCRIPTIONS
S1-16 AND INT-11 AREAS

S1-16A	24'	Water sample. No recovered DNAPL.
	28'	Water sample. No recovered DNAPL.
S1-16C	31-32.5'	Barrel did not open. Red clay at base of sampler.
	30.5-32'	Moved 2 feet. Lost sample. Mostly sand. Oil remnant in core barrel.
S1-16G	33-33.2'	Sand, gray to blk., m. to c. gr.. Chemical smell, residual DNAPL. No evidence of mobile product.
	33.2-33.5'	Clay, white, silty, with nodules. Chemical smell but no visible staining.
	33.5-34.5	Clay, red, mottled with gray silt and f. gr. sand. No DNAPL evident.
S1-16H	33-33.5'	Clay, red. No DNAPL
	33.5-33.8'	Sand, red, f. gr,. No DNAPL.
	33.8-34.5'	Clay, red. No DNAPL.
INT-11A	46'	Water sample. No recovered DNAPL.
	49'	Water sample. No recovered DNAPL.
INT-11B	33-34'	Sand, gray, f. gr., clean.
	34-34.5'	Sand, silty, gray, with thin tan-red clay streaks. Black carbonaceous streaks. Smelled of chemicals but no reading on OVM.
	48-48.8'	Sand, gray, f. gr., chemical odor but no visible staining.
	48.8-49.5'	Sand, highly stained, organics in fine stratifications. Organic is residual, tarry texture, not fluid although can be mobilized when wet.
INT-11C	33.5-35'	Sand, lt. gray, f. gr., chemical odor. Spotty, "concretion-like" nodules of organic residual. Noted brownish discoloration in isolated stratified zones which cleave easily. No noticeable grain size difference.
	48.5-50'	Lost soil sample. Oil residue on barrel.
INT-11D	48.5-49.5'	Sand, gray, f. gr., compacted. Chemical odor and light brown chemical staining evident.
	49.5-50'	Sand, dc. bwn., f. gr., organic saturated, above clayey silt to f. gr. sand. Organic material tends to accentuate stratification in f. gr sands. Organic staining peters out in underlying silty/clayey zone.
INT-11E	48.5-50'	Lost soil sample. Core barrel had an oily residue.
INT-11F	49-50'	Sand, f. to m. gr. Impregnated with black organic residue material. High clay content. Sample dense but malleable. No evidence of free liquid organics. Organic appears to be immobile.
	50-50.5'	Clay, dk. bwn., interbedded with silt and f. gr. sand. Organic residual does not penetrate into clay, but some of the silt/f. gr. sand streaks are stained.
INT-11G	49-50.5'	Lost soil sample. No evidence of oil in soil barrel.
	51.5-53'	Lost soil sample. No evidence of oil in soil barrel.

072572

TABLE 3

VOLATILE ORGANIC ANALYSIS - WELL INT-64
INT-11 AREA

Well INT-64	15-17'	24-26'	27-29'	31-32'	41-43'	50-52'
Parameter	ppb	ppb	ppb	ppb	ppb	ppb
Chloromethane	BDL	BDL	BDL	BDL	BDL	BDL
Bromomethane	BDL	BDL	BDL	BDL	BDL	BDL
Vinyl Chloride	BDL	BDL	BDL	BDL	BDL	BDL
Chloroethane	BDL	BDL	BDL	BDL	BDL	BDL
Methylene Chloride	61	130	120	110	*4900	*5100
Acetone	24	12	*1900	*560	2400	3400
Carbon Disulfide	13	34	BDL	BDL	31000	2800
1,1-Dichloroethene	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethane	BDL	BDL	BDL	BDL	BDL	BDL
Trans 1,2-Dichloroethene	BDL	10	43	BDL	BDL	BDL
Chloroform	8	30	220	BDL	830	1000
1,2-Dichloroethane	14	140	1500	260	2800	4400
2-Butanone	BDL	BDL	390	100	BDL	BDL
1,1,1-Trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL
Carbon Tetrachloride	BDL	BDL	BDL	BDL	BDL	BDL
Vinyl Acetate	BDL	BDL	320	75	BDL	BDL
Bromodichloromethane	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloropropane	BDL	BDL	BDL	BDL	BDL	BDL
Cis 1,3-Dichloropropene	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethene	BDL	BDL	BDL	BDL	BDL	BDL
Dibromochloromethane	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL
Benzene	BDL	BDL	BDL	BDL	BDL	BDL
Trans 1,3-Dichloropropene	BDL	BDL	BDL	BDL	BDL	BDL
2-Chloroethylvinylether	BDL	BDL	BDL	BDL	BDL	BDL
Bromoform	BDL	BDL	BDL	BDL	BDL	BDL
4-Methyl 2-Pentanone	BDL	BDL	190	BDL	BDL	BDL
2-Hexanone	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethene	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2,2-Tetrachloroethane	BDL	BDL	BDL	BDL	BDL	BDL
Toluene	BDL	BDL	BDL	BDL	BDL	BDL
Chlorobenzene	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	BDL	BDL	86	BDL	BDL	BDL
Styrene	BDL	BDL	BDL	BDL	BDL	BDL
Total Xylenes	BDL	BDL	BDL	BDL	BDL	BDL

* Compound Detected in the QC Blank

TABLE 4

ANALYSIS OF DNAPL SAMPLES FROM INT-11B AND INT-11C

Analyte:	INT-11B	INT-11B(dup)	INT-11C	
	mg/kg	mg/kg	mg/kg	
Total organic carbon	38,900	39,200	31,700	
Total organic halogens	80,300	79,000	112,000	
Total petroleum hydrocarbons	97,100		69,500	
VOCs:	**INT-11B (1:1.6)**	**INT-11B (1:310)**	**INT-11C (1:1.6)**	**INT-11C (1:310)**
	mg/kg	mg/kg	mg/kg	mg/kg
Vinyl chloride	8J			
Chlorethane	140		5J	
Methylene chloride	210		49	
Acetone				2100J
Carbon disulfide	16		3J	
1,1-Dichloroethene	300		50	
1,1-Dichloroethane	970	520J	380	
1,2-Dichloroethene (total)	7,200	5,000	2,900	
Chloroform	12,000	27,000	8,700	9,200
1,2-Dichloroethane	13,000	12,000	9,100	9,200
2-Butanone			18	
1,1,1-Trichloroethane			4J	
Carbon tetrachloride	7,000	26,000	5,600	7,500
Trichloroethene	700	700J	480	
1,1,2-Trichloroethane	12		8J	
Benzene	27		21	
4-Methyl-2-pentanone	54		40	
2-Hexanone	7J		4J	
Tetrachloroethene	3,700	13,000	3,500	4,500
1,1,2,2-Tetrachloroethane	130		100	
Toluene	90		51	
Ethylbenzene	87		54	
Xylenes (total)	250		170	
Tentatively Identified:				
Ethane, pentachloro-	690		340	
SVOCs:	**INT-11B**		**INT-11C**	
	mg/kg		mg/kg	
Hexachloroethane	5,800J		2,200J	
Naphthalene	1,600J		660J	
Hexachlorobutadiene	38,000		17,000	
2-Methylnaphthalene	350J			
Acenaphthene	610J			
Dibenzofuran	360J			
Fluorene	600J			
Phenanthrene	1,000J		410J	
Tentatively Identified:				
1,3-Butadiene, pentachloro-	5,900			
Aliphatic hydrocarbon	7,300			

Only compounds detected are shown
J = present, but below the detection limit